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**(54) Ultra light engine valve**

Ultraleichtes Ventil für Brennkraftmaschine

Souape pour moteur ultra légère

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• PATENT ABSTRACTS OF JAPAN vol. 12, no. 347  
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**Description**

[0001] The present invention relates generally to poppet valves for internal combustion engines, and more particularly to a valve which is of exceptionally light weight while maintaining high strength-to-weight characteristics.

5 [0002] Internal combustion engine poppet valves are most commonly fabricated by machining, forging or extruding a solid blank of high-strength, heat resistant metal and then subjecting the blank to finish machining and/or grinding operations. In some applications, performance requirements make it necessary to provide a valve having a hollow stem into which a coolant such as sodium may be added during the fabrication process. In the prior art, such hollow stems have been formed by means such as drilling the stem or by extruding or forging the stem over a mandrel or a removable  
10 core. United States Patent No. 5,054,195 discloses a poppet valve which is fabricated by cold forming a tubular blank to a desired stem diameter, shaping the transition region between the stem diameter and the blank diameter into an arc to define the fillet portion of the valve by means of a kneading process or the like, cutting off the blank at or near the outer diameter of the fillet portion, attaching a cap which defines the head of the valve, and then adding an additional part to close the cavity at the tip end of the valve. A known hot extrusion process is described in JP-A-63 109206, in this  
15 hot extrusion process a block is formed and extruded to form a valve stem, following which a cap is secured in place. Another form of known valve is described in FR-A-2 072 186, in which part of the stem is hollow but the tip region is of solid construction.

20 [0003] JP 63-306212 discloses a hollow engine valve. A weight saving over other valves is made by use of a pipe for the stem portion with a flared end portion. A cap is attached to the flared end by a subsequent process. The hollow stem portion is closed off at the other end of the pipe portion by insertion of a plug or filler member. It is also suggested that another method of forming a pipe closed at one end is by use of a deep drawing process.

25 [0004] While hollow valves produced by the known fabrication process are significantly lighter than prior art solid valves, increasingly stringent standards of performance, fuel economy and emission control require further weight reduction which is not considered to be economically attainable by the prior art processes. Furthermore, current development work in camless valve actuation, wherein the valve is opened and closed directly by an electrical or fluid actuator, impose valve mass limitations to avoid the excessive actuation energy which would be required by the mass of conventional valves.

30 [0005] To meet the objective of minimum weight, the present invention provides an ultra-light poppet valve which comprises a stem portion, a cap portion, a tip portion and a flared fillet portion defining a transition region between said stem portion and said cap portion, said cap portion being defined by a disk-like cap member fixed to said fillet portion; and wherein said stem portion, said tip portion and said fillet portion are defined by a one-piece, hollow cylindrical member which is open at the fillet end thereof and closed at the tip end; characterized in that said one piece hollow cylindrical member is made from a ductile metal sheet, formed such that said fillet portion has a first maximum wall thickness  $t_1$ , said stem portion has a second maximum wall thickness  $t_2$  thinner than said first maximum wall thickness, and said tip portion has a third wall thickness  $t_3$  thicker than said second maximum wall thickness.

35 [0006] According to another aspect of the present invention there is provided a method for manufacturing such an ultra light poppet valve for an internal combustion engine characterized by the steps of providing a flat metal blank, subjecting said blank to a plurality of cold forming steps wherein mandrels of decreasing diameter and increasing length are sequentially engaged with said blank to draw said blank into an elongated cylinder having a substantially flat closed  
40 end and a flared open end, and welding a substantially disk-like cap member to said flared end.

45 [0007] In a preferred embodiment, the valve seat face is formed on the cap element, while in alternative embodiments the seat face is formed as part of the weld joint between the fillet and stem element or on the stem element. In accordance with the invention, the stem element is in the form of a cup having a flared open end defining the fillet region of the valve and a closed end defining the tip, and is hollow all the way to the tip. In accordance with the invention, the wall section of the stem element is relatively thick in the fillet region, tapers down to a substantially uniform thickness for the rest of the length of the stem, and is again relatively thick at the tip end.

50 [0008] In the present invention, the stem element is fabricated by means of a deep drawing process wherein a starting blank in the form of a sheet-like disk is subjected to a plurality of cold drawing steps which result in an elongated flared cup wherein the outer edge of the flared end and the tip end are substantially of the thickness of the starting blank. In accordance with one aspect of the invention, one or more keeper grooves is rolled into the hollow stem as an added step to the drawing process.

55 [0009] Heretofore, the deep drawing process used in accordance with the invention has not been considered to be practical for fabricating engine valves, and particularly exhaust valves, because materials having sufficient ductility to be deep drawn have not been considered to have sufficient hot strength properties for use in engine valves. The present invention, however, utilizes a drawn stem element in combination with cooling and strength enhancing features which make the use of high ductility materials practical for this application.

[0010] In accordance with other aspects of the invention, the cap element is optimally shaped to enhance the strength and rigidity of the valve, and the cap is welded to the stem in a region where there is an optimum stress/tem-

perature relationship, and in accordance with alternative embodiments, the cap includes ribs which serve to increase the stiffness of the combustion face of the valve and to improve heat transfer between the combustion face and an internal coolant.

- 5 [0011] Other aspects and advantages of the invention will be apparent from the following description when considered in connection with the accompanying drawings, wherein:

Fig. 1 is a cross sectional view of a valve in accordance with the present invention;  
 Fig. 1a is a partial cross sectional view showing an alternative design for the tip portion of the valve of Fig. 1;  
 Fig. 2a is an enlarged sectional view of the cap portion of the valve shown in Fig. 1;  
 10 Figs. 2b and 2c are sectional views of alternative embodiments of the cap portion shown in Fig. 2a;  
 Figs. 3a - 3d are schematic sectional views of various steps in the fabrication of the stem portion of the valve shown in Fig. 1.  
 Fig. 4 is a fragmentary sectional view of showing a method for forming a keeper groove in the stem portion.  
 Fig. 5 is a sectional view taken along line 5-5 of Fig. 4.  
 15 Figs. 6a - 6c illustrate typical stress and temperature distributions on the surface of a prior art exhaust valve;  
 Figs. 7a - 7c illustrate typical stress and temperature distributions on the surface of an exhaust valve in accordance with the present invention.  
 Fig. 8 is a fragmentary sectional view of an alternative embodiment of the invention;  
 Fig. 9 is a sectional view taken along line 9-9 of Fig 8;  
 20 Figs. 10 - 12 are fragmentary cross sectional views of further alternative embodiments of the invention;  
 Fig. 13a is a sectional view of a prior art solid valve;  
 Fig. 13b is a sectional view of a prior art hollow valve; and  
 Fig. 13c is a sectional view of a valve of the invention shown in substantially the same scale as Figs. 13a and 13b.

- 25 [0012] Referring to Fig. 1, there is illustrated a poppet valve 10 comprising a stem element 12 and a cap member 14 welded or otherwise joined to the stem element. In the preferred embodiment, the stem element for an intake valve can be fabricated using a ductile metal sheet product such as SAE 1008 steel, while the stem element for an exhaust valve can be fabricated using a stainless steel such as UNS305 or Incoloy 800, the cap being formed of a stainless steel or other compatible material in either case. It can be appreciated that the specific materials will vary depending on the 30 engine application.

- [0013] As will be described in further detail below, the stem element 12 is formed by a deep drawing process which results in a first wall thickness  $t_1$  in the fillet region 16 and which is a maximum at the outer extremity of the fillet region; is at a second thickness  $t_2$  less than  $t_1$  throughout the length of the stem, and which is at a third thickness  $t_3$  at the tip 18 which is approximately the same as thickness  $t_1$ . Fig. 1a shows an alternative tip design wherein the tip 18a includes 35 a bevel 19 to increase the stiffness of the tip end of the valve. In the example illustrated, the bevel is preferably formed at an angle of  $40 \pm 10^\circ$ .

- [0014] Referring particularly to Fig. 2a, the cap member 14 is a disk which is preferably formed with a convex combustion face 22 and a concave internal face 23. A seat face 20 can be formed by machining, deposition and machining or other known methods. In the preferred embodiment, the strength to weight ratio of the disk is maximized by tapering 40 the wall from the outside in such that the angle  $b$  is greater than the angle  $a$ . In the preferred embodiment, the angle  $a$  is about  $5^\circ$  to a line perpendicular to the longitudinal axis of the stem, and the angle  $b$  is about  $10^\circ$  to such line. While the above represents a preferred embodiment, configurations wherein angle  $a$  is equal to angle  $b$  as shown in Fig. 2b and wherein angle  $a$  is greater than angle  $b$  as shown in Fig. 2c, can also be used.

- [0015] In the preferred embodiment, the cap is welded to the stem element at 24, and a keeper groove 26 is rolled 45 into the stem wall near the tip end of the valve. The weld 24, which can be done by a variety of known processes including laser, TIG, MIG, EB and resistance weld techniques, is located at the interface between the outer edge of the fillet 16 and a surface 25 formed on the cap adjacent the seat face, which, as will be described below, is an area of relatively lower temperature and thus higher material strength properties than adjacent areas. In applications wherein the valve is opened and closed directly by a fluid or electrical actuator, it may not be necessary to include a keeper groove.

- 50 [0016] In accordance with the invention, the stem element is formed by means of a cold forming process known as deep drawing, which is typically carried out on a so-called transfer press. In this process, a series of drawing steps is carried out on a workpiece which starts out as a flat sheet disk and which is stepwise transferred from one set of drawing tools to another with a plurality of the steps being carried out within a single transfer machine but wherein each of the steps is individually cam operated. The result of this process is the transformation of the flat disk into an elongated 55 cup member formed to near net diameters and of exceptional straightness. The process is capable of producing parts which have exceptionally thin walls but of relatively high strength due to the inherent cold working of the material in the course of the drawing process.

[0017] Referring to Figs. 3a - 3d, there is schematically illustrated several typical steps in the transfer process start-

ing with a sheet disk 12(a) in Fig. 3a and progressing through a number of intermediate steps, depending on the final length of the valve, as illustrated by Figs. 3b and 3c; wherein the workpiece is held in fixtures 28b - 28d, while cam-actuated plungers or mandrels 30b - 30d are engaged with the workpiece to draw it to the desired shape. Additional steps to trim the open flared end, to true the radius of the fillet portion and to obtain the final diameter of the stem portion can also be made in the course of or after completion of the drawing process. A further pressing operation may also be carried out to insure that the tip of the valve is in its desired final shape (flat in the illustrative embodiments).

[0018] Referring to Figs. 4 and 5, the present invention can also include a step wherein the keeper groove 26 is formed as a part of the cold forming process. In this step, the workpiece in its nearly completed form is transferred to a station within the transfer press wherein the workpiece is received between two dies 32 and 34 which are geared or otherwise linked together to move in opposite directions, as indicated by the arrows in Fig. 5, to roll the workpiece between them. To form the groove 26, the die 32 has a knurled or other high friction surface 33 formed thereon to grip the workpiece, and the die 34 has a projection 35 thereon in the form of a ramp to displace the material of the workpiece wall to form the keeper groove. Other methods of forming the groove can also be used, including a plurality of radially movable circular dies in surrounding relation to the workpiece. Because of the displacement of the material, the final steps to insure the shape of the tip end as well as to obtain the final dimensions of the stem portion are carried out after the groove rolling step. A single groove is shown herein; however, it can be appreciated that multiple grooves of varied shape can be formed if required for a particular engine design, or to provide additional stiffness.

[0019] The final stem element 12 which results from the above process is characterized by an integral tip end and by a very thin wall through the length of the straight portion of the stem but wherein the thickness  $t_1$  and  $t_3$  in the areas 20 of the fillet and the tip respectively are essentially the thickness of the original metal sheet 12a in Fig. 3a.

[0020] The significance of the wall thickness relationships and the design of the cap 14 can be appreciated by reference to Figs. 6 and 7, which provide comparative temperature, stress and strength profiles for similarly configured hollow exhaust valves 50% filled with sodium potassium coolant.

[0021] Figs. 6a - 6c depict a drilled prior art valve fabricated from a 400 series martensitic stainless steel or a 21-2n stainless steel, and include results derived from experimental data and/or finite element analysis. Figs. 7a - 7c depict a valve in accordance with the invention, and include results derived empirically and/or by finite element analysis.

[0022] Referring to Figs. 6b and 6c, it can be observed that both the maximum stress and the maximum temperature occur in the fillet area about midway between the centerline and the seat face, and that the pronounced peak in the temperature curve at this point results in a corresponding trough in the material strength curve.

[0023] Figs. 7b and 7c represent characteristics which can be expected to be obtained in the inventive valve, wherein the extremely thin wall construction results in improved heat transfer characteristics and an improved stress profile. It can be observed that while the maximum temperature occurs in the same area as in the prior art valve, the temperature curve is nearly flat. In the inventive valve, the extremely thin wall section of the stem portion combined with a cap design bridging the flared fillet portion of the stem tends to move the area of highest stress outward from the centerline of the valve toward the outer edge of the valve where the temperature is at a relatively low level. It can be seen in Fig. 7c that the area of maximum stress is at a point at least 70% of the radial distance from the center of the valve. This separation of the area of maximum stress from the area of maximum temperature provides more flexibility in the choice of materials which can be used, since the material strength properties are greater at lower temperatures. The relative flatness of the strength curve also contributes to greater flexibility in the choice of materials. Another advantage 40 of this construction is that the weld joint between the stem portion and the cap can also be located in a relatively low temperature area.

[0024] Referring again to Fig. 2a, the location and level of maximum stress is affected to a significant degree by the design of the cap 14, with the preferred embodiment illustrated therein providing an optimum combination of maximized strength and stiffness and minimized weight. Referring to Figs. 8 and 9, there is illustrated an alternative embodiment 45 of the invention wherein the cap 14b has a flat combustion face 22a and wherein a plurality of ribs 28 are formed on the inner face as shown in full line in Fig. 8 or on the combustion face 28' as shown in broken line. The ribs act as stiffeners for the cap and essentially serve the same function as the angled configuration of the Fig. 1 embodiment. The ribs further act to increase the surface area of the cap to improve heat transfer.

[0025] Referring to Fig. 10, there is shown an alternative embodiment wherein the cap 14d is dimensioned to leave 50 a gap in the area of the seat face. This gap is filled with a hard seat facing material such as Stellite or other known hard-facing material and then finished to the final seat face configuration to define a hardened seat face 20a as well as to attach the cap to the stem element 12a. Such construction is used in applications where an extremely hard seat face is required, such as in aircraft engines, and combines the attachment of the cap to the stem element and the formation of the hard seat face into a single operation.

[0026] In the embodiment shown in Fig. 11, the stem element 12b is formed such that the seat face 20b is formed 55 on the stem element, and the cap 14b fits inside the stem element and is welded thereto at 38. In the embodiment shown, the cap is formed with a flat combustion face; however, it can be understood that the cap can be formed in a variety of specific shapes including those described herein, and can also include the rib configurations described

above.

[0027] Fig. 12 illustrates an embodiment wherein the seat face 20c is formed on the stem element and the cap 14c is butt welded to the stem element at 39. Again, the specific shape of the cap can be varied as described with respect to Fig. 11.

5 [0028] While the valve 10 of the invention can be used without the addition of a coolant, particularly as an intake valve, to take advantage of its extreme light weight, it is expected that for exhaust valve applications a coolant such as sodium potassium (NaK) or water will be added to a selected level designated 42 and shown in broken line in Fig. 1 prior to completing the welding of cap 14 to stem element 12 to enhance cooling. While the addition of such coolant is well known in the art, the extremely thin wall section of the present valve significantly increases the volume available for 10 the coolant and increases the heat transfer area exposed to the coolant as illustrated by comparing Figs. 13b and 13c. Also, since in coolant-filled valves the valve wall acts as a barrier to heat transfer from the internal coolant to the external cylinder head valve guide, the extremely thin wall section of the valve of the invention minimizes this barrier effect.

15 [0029] While adding an internal coolant to an exhaust valve is well known, the addition of such coolant to an intake valve has demonstrated a significant decrease in deposits along the fillet region in certain applications. The increased cooling effect of a valve in accordance with the present invention can be expected to further decrease such deposits.

20 [0030] Figures 13a, 13b and 13c show engine valves of the same stem and head diameter and the same length but using three different structures. Fig. 13a shows a prior art solid valve, Fig. 13b shows a prior art valve having a drilled stem, and Fig. 13c shows a valve in accordance with the present invention. Table 1 below compares specifications for a typical passenger car engine valve using calculated values for displaced volume (i.e. total volume of the exterior valve envelope) and weight and the use of similar materials.

TABLE 1

	Head Dia.	Stem Dia.	Length	Displ. Vol.	Min. Wall Thick.	Empty Wt.	Total Wt. 50% NaK
Fig. 13a	28mm	6mm	100mm	5.2cc	N.A.	41g	N.A.
Fig. 13b	28mm	6mm	100mm	5.2cc	0.75mm	32g	33g
Fig. 13c	28mm	6mm	100mm	5.2cc	0.50mm	17g	19g

25 [0031] Referring to the table, it can be seen that the valve in accordance with the invention is 59% lighter than a solid valve of the same dimensions and 47% lighter than the drilled valve in the empty state. It can also be seen that even when a coolant, specifically a 50% fill of NaK, is added to the valve in accordance with the present invention, there 30 is still a significant weight advantage.

35 [0032] The valve of Fig. 13c illustrates a typical valve made in accordance with the invention, and the minimum wall thickness of .50mm is intended to show a minimum for the illustrative valve only, not an absolute minimum. Even thinner wall sections can be achieved if a coolant which vaporizes at the valve operating temperature is added since the increased internal pressure which results when the coolant is vaporized will add stiffness to the valve structure, much 40 in the way that an aluminum can is stiffened when filled with a carbonated beverage.

45 [0033] Table 2 compares internal and external stem diameters and the total or displaced volume and cavity volume for a series of actual prior art intake and exhaust valve designs of the configuration of Fig. 13b and for actual designs of the inventive configuration as shown in Fig. 13c.

45

TABLE 2

Design Fig.	Type	Cavity Dia. (mm)	Stem Dia. (mm)	Dia. Ratio	Displ. Vol. (cc)	Cavity Vol. (cc)	Vol. Ratio
13b (1)	Ex.	6.35	10.2	1.606	17.72	2.88	6.153
13b (2)	Ex.	6.35	9.4	1.480	16.28	2.88	5.653
13b (3)	In.	7.00	8.5	1.214	14.59	3.99	3.657
13b (4)	In.	5.50	7.0	1.273	11.20	2.32	4.828
13b (5)	Ex.	7.00	8.5	1.214	11.62	3.19	3.643
13b (6)	In.	7.20	8.7	1.208	13.62	4.04	3.371

TABLE 2 (continued)

Design Fig.	Type	Cavity Dia. (mm)	Stem Dia. (mm)	Dia. Ratio	Displ. Vol. (cc)	Cavity Vol. (cc)	Vol. Ratio	
5	13b (7)	Ex.	7.20	8.7	1.208	11.78	3.61	3.263
	13b (8)	In.	5.50	7.0	1.272	7.15	2.10	3.405
10	13b (9)	In.	5.50	7.0	1.273	5.51	1.21	4.554
	13b (10)	Ex.	4.50	6.0	1.333	6.07	1.85	3.281
15	13b (11)	Ex.	4.50	6.0	1.333	4.76	1.05	4.533
	13b (12)	In.	4.50	6.0	1.333	5.05	1.26	4.088
	13b (13)	Ex.	4.50	6.0	1.333	4.37	1.20	3.642
13c (1)	13c (1)	Ex.	5.00	6.0	1.200	5.12	2.33	1.809
	13c (2)	In.	5.00	6.0	1.200	6.13	3.46	1.772

## Claims

- 20 1. An ultra light poppet valve (10) for an internal combustion engine comprising a stem portion (12), a cap portion (14), a tip portion (18) and a flared fillet portion (16) defining a transition region between said stem portion and said cap portion; said cap portion being defined by a disk-like cap member fixed to said fillet portion, and wherein said stem portion, said tip portion and said fillet portion are defined by a one-piece, hollow cylindrical member which is open at the fillet end thereof and closed at the tip end, characterised in that said one-piece hollow cylindrical member is made from a ductile metal sheet formed such that said fillet portion has a first maximum wall thickness  $t_1$ , said stem portion has a second maximum wall thickness  $t_2$  thinner than said first maximum wall thickness, and said tip portion has a third wall thickness  $t_3$  thicker than said second maximum wall thickness.
- 25 2. A valve as claimed in claim 1 in which said third wall thickness  $t_3$  of the tip portion is substantially uniform and said first maximum wall thickness  $t_1$  of said fillet portion and said third wall thickness  $t_3$  are substantially equal.
- 30 3. A valve as claimed in claims 1 or 2 in which said first maximum wall thickness  $t_1$  of the fillet portion and said third wall thickness  $t_3$  of the tip portion are substantially equal and substantially the same thickness as the ductile metal sheet from which the hollow cylindrical member is made
- 35 4. A valve as claimed in claims 2 or 3 including a beveled surface (19) formed at the intersection of said stem portion and said tip portion.
- 40 5. A valve as claimed in claim 4 in which said beveled surface is formed at an angle of  $40 \pm 10^\circ$ .
6. A valve as claimed in claim 1 in which the top surface of said cap member defines a combustion face (22) exposed to combustion pressures generated by said engine; said surface being a surface of revolution formed at a first angle (a) to a line perpendicular to the longitudinal axis of said stem portion and the surface opposite said combustion surface being formed at a second angle (b) to said line perpendicular to the longitudinal axis of said stem portion.
- 45 7. A valve as claimed in claim 6 in which said first angle is zero degrees and said second angle is zero degrees.
8. A valve as claimed in claim 6 in which said first and second angles are each greater than zero degrees and are equal.
- 50 9. A valve as claimed in claim 6 in which said first angle is greater than said second angle.
10. A valve as claimed in claim 6 in which said first angle is less than said second angle.
- 55 11. A valve as claimed in any one of claims 6 through 10 in which said cap member has one or more radially disposed ribs (28) formed thereon.

12. A valve as claimed in claim 1 wherein said valve includes a valve seat engaging face (20) formed on said cap member.
- 5        13. A valve as claimed in claim 1 wherein said valve includes a valve seat engaging face (20b, 20c) formed on said fillet portion.
- 10      14. A valve as claimed in claim 1 in which said stem portion has a wall section which is sufficiently thin to cause the point of maximum stress in said valve due to combustion pressures generated by said engine to be located at a point at least 70% of the radial distance from the longitudinal centreline to the outer edge of the valve.
- 15      15. A valve as claimed in claim 1 in which the ratio of the external diameter to the internal diameter in the region between the fillet portion and the extreme end of the tip portion is less than 1.25.
16. A valve as claimed in any one of claims 1 through 15 including one or more grooves (26) formed in the stem portion thereof.
- 20      17. A method for manufacturing an ultra light poppet valve (10) according to any preceding claim for an internal combustion engine characterised by the steps of providing a flat metal blank, subjecting said blank (12a) to a plurality of cold forming steps wherein mandrels (30b, 30c, 30d) of decreasing diameter and increasing length are sequentially engaged with said blank to draw said blank into an elongated cylinder (12, 16, 18) having a substantially flat closed end and a flared open end, and welding a substantially disk-like cap member to said flared end.
- 25      18. A method as claimed in claim 17 including the step of forming an annular groove in said cylinder by inwardly displacing the wall of said cylinder.
- 29      19. A method as claimed in claim 18 in which said wall is displaced by gripping said cylinder between surfaces of parallel tool elements (32, 34) and moving said tool elements in opposite directions parallel to said surfaces, wherein one of said tool elements has a ramp-like projection (35) formed thereon.
- 30      20. A method as claimed in claim 19 in which the other tool element has a friction surface formed thereon engageable with said cylinder.
- 35      21. A method as claimed in any one of claims 17 through 20 including the step of adding a coolant to the interior of said valve prior to said welding step.

#### Patentansprüche

1. Ultraleichtes Sitzventil (10) für einen Verbrennungsmotor, wobei folgendes vorgesehen ist: einen Schafteil (12), einen Kappenteil (14), einen End- oder Spitzenteil (18) und einen sich erweiternden Kehl- bzw. Übergangsteil (16), welcher eine Übergangsregion bildet zwischen dem Schafteil und dem Kappenteil, wobei der Kappenteil durch ein scheibenartiges Kappenglied befestigt an dem Kehl- bzw. Übergangsteil definiert ist; und wobei der Schafteil, der Endteil und der Kehl- bzw. Übergangsteil durch ein einstückiges hohles zylindrisches Glied definiert sind, welches am Kehl- bzw. Übergangsende offen und am spitzen Ende geschlossen ist, dadurch gekennzeichnet, daß das einstückige hohle zylindrische Glied aus einem duktilen bzw. verformbaren oder ziehfähigen Metallblech hergestellt ist, das so geformt ist, daß der Kehl- bzw. Übergangsteil eine erste maximale Wanddicke  $t_1$  besitzt, der Schafteil eine zweite maximale Wanddicke  $t_2$  besitzt, dünner als die erste maximale Wanddicke, und der End- oder Spitzenteil eine dritte Wanddicke  $t_3$  besitzt, die dicker ist als die zweite maximale Wanddicke.
2. Ventil nach Anspruch 1, wobei die dritte Wanddicke  $t_3$  des End- oder Spitzenteils im wesentlichen gleichförmig ist und wobei die erste maximale Wanddicke  $t_1$  des Kehl- bzw. Übergangsteils und die dritte Wanddicke  $t_3$  im wesentlichen gleich sind.
3. Ventil nach Anspruch 1 oder 2, wobei die erste maximale Wanddicke  $t_1$  des Kehl- bzw. Übergangsteils und die dritte Wanddicke  $t_3$  des End- bzw. Spitzenteils im wesentlichen gleich sind und im wesentlichen die gleiche Dicke wie das duktile Metallblech besitzen, aus dem das hohle zylindrische Glied gefertigt ist.
4. Ventil nach Anspruch 2 oder 3 mit einer sich verjüngenden Oberfläche (19), gebildet am Schnitt von Schafteil und Endteil.

5. Ventil nach Anspruch 4, wobei die verjüngte Oberfläche mit einem Winkel von  $40 \pm 10^\circ$  gebildet ist.
6. Ventil nach Anspruch 1, wobei die obere Oberfläche (Oberseite) des Kappenglieds eine Verbrennungsstirnseite (22) definiert, und zwar ausgesetzt gegenüber durch den Motor erzeugten Verbrennungsdrücken; wobei die Oberfläche eine Drehoberfläche ist, gebildet mit einem ersten Winkel (a) gegenüber einer Linie senkrecht zur Längsachse des Schafteils, und wobei die Oberfläche entgegengesetzt zu der Verbrennungsoberfläche unter einem zweiten Winkel (b) gebildet ist, und zwar gegenüber der Linie senkrecht zur Längsachse des Schafteils.
7. Ventil nach Anspruch 6, wobei der erste Winkel  $0^\circ$  ist und wobei der zweite Winkel  $0^\circ$  ist.
8. Ventil nach Anspruch 6, wobei die ersten und zweiten Winkel jeweils größer sind als  $0^\circ$  und gleich sind.
9. Ventil nach Anspruch 6, wobei der erste Winkel größer als der zweite Winkel ist.
10. Ventil nach Anspruch 6, wobei der erste Winkel kleiner ist als der zweite Winkel.
11. Ventil nach einem der Ansprüche 6 bis 10, wobei das Kappenglied eine oder mehrere radial angeordnete daran ausgeformte Rippen (28) aufweist.
12. Ventil nach Anspruch 1, wobei das Ventil eine Ventilsitzeingriffsfläche (20), geformt an dem Kappenglied, aufweist.
13. Ventil nach Anspruch 1, wobei das Ventil eine Ventilsitzeingriffsfläche oder -stirnseite (20b, 20c) aufweist, und zwar gebildet an dem Kehl- bzw. Übergangsteil.
14. Ventil nach Anspruch 1, wobei der Schafteil einen Wandabschnitt aufweist, der hinreichend dünn ist, um zu bewirken, daß der Punkt maximaler Beanspruchung in dem Ventil infolge von Verbrennungsdrücken, erzeugt durch den Motor, an einem Punkt angeordnet ist, der mindestens 70% des Radialabstandes von der Längsmittellinie zur Außenkante des Ventils angeordnet ist.
15. Ventil nach Anspruch 1, wobei das Verhältnis von Außendurchmesser zu Innendurchmesser im Bereich der Zone oder Region zwischen dem Übergangsteil und dem äußeren Ende des Spitzen- oder Endteils kleiner als 1,25 ist.
16. Ventil nach einem der Ansprüche 1 bis 15 mit einer oder mehreren Nuten (26), ausgeformt im Schafteil davon.
17. Verfahren zur Herstellung eines ultraleichten Sitzventils (10) gemäß einem der vorhergehenden Ansprüche für einen Verbrennungsmotor, gekennzeichnet durch die folgenden Schritte: Vorsehen eines flachen Metallrohlings, Aussetzen des Rohlings (12a) einer Vielzahl von Kaliformsschritten, wobei Dorne (30b, 30c, 30d) von abnehmendem Durchmesser und ansteigender Länge sequentiell mit dem Rohling in Eingriff kommen, um den Rohling in einen langgestreckten Zylinder (12, 16, 18) zu ziehen, und zwar mit einem im wesentlichen flachen geschlossenen Ende und einem sich erweiternden offenen Ende, und Schweißen eines im wesentlichen scheibenartigen Kappengliedes an das sich erweiternde Ende.
18. Verfahren nach Anspruch 17 einschließlich des Schrittes des Formens einer Ringnut in dem Zylinder durch Innenversetzung bzw. Umformung nach innen der Wand des Zylinders.
19. Verfahren nach Anspruch 18, wobei die Wand versetzt bzw. verformt wird, und zwar durch Ergreifen des Zylinders zwischen den Oberflächen paralleler Werkzeugelemente (32, 34) und durch Bewegung der Werkzeugelemente in entgegengesetzten Richtungen parallel zu den Oberflächen, wobei eines der Werkzeugelemente einen rampenartigen Vorsprung (35), darauf gebildet, aufweist.
20. Verfahren nach Anspruch 19, wobei das andere Werkzeugelement eine Reibungsoberfläche, ausgeformt darauf und in Eingriff bringbar mit dem Zylinder, aufweist.
21. Verfahren nach einem der Ansprüche 17 bis 20 einschließlich des Schrittes des Hinzufügens bzw. Einfüllens eines Kühlmittels in das Innere des Ventils vor dem Schweißschritt.

**Revendications**

1. Soupape à champignon ultralégère (10) pour un moteur à combustion interne comprenant une partie tige (12), une partie bouchon (14), une partie pied (18) et une partie évasée congé (16) définissant une zone de transition entre ladite partie tige et ladite partie bouchon ; ladite partie bouchon étant définie par un élément bouchon en forme de disque fixé à ladite partie congé, et dans laquelle ladite partie tige, ladite partie pied et ladite partie congé sont définies par un élément cylindrique creux d'une seule pièce qui est ouvert côté congé et fermé côté pied, caractérisée en ce que ledit élément cylindrique creux d'une seule pièce est fabriqué à partir d'une tôle ductile formée de telle manière que ladite partie congé a une première épaisseur de paroi maximale  $t_1$ , ladite partie tige a une deuxième épaisseur de paroi maximale  $t_2$  plus fine que ladite première épaisseur de paroi maximale et ladite partie pied a une troisième épaisseur de paroi  $t_3$  plus épaisse que ladite deuxième épaisseur de paroi maximale.
2. Soupape selon la revendication 1, dans laquelle ladite troisième épaisseur de paroi  $t_3$  de la partie pied est sensiblement uniforme et ladite première épaisseur de paroi maximale  $t_1$  de ladite partie congé et ladite troisième épaisseur de paroi  $t_3$  sont sensiblement égales.
3. Soupape selon les revendications 1 ou 2, dans laquelle ladite première épaisseur de paroi maximale  $t_1$  de la partie congé et ladite troisième épaisseur de paroi  $t_3$  de la partie pied sont sensiblement égales et sensiblement de la même épaisseur que la tôle ductile à partir de laquelle l'élément cylindrique creux est fabriqué.
4. Soupape selon les revendications 2 ou 3 comprenant une surface conique (19) formée à l'intersection de ladite partie tige et de ladite partie pointe.
5. Soupape selon la revendication 4, dans laquelle ladite surface conique est formée sous un angle de  $40 \pm 10^\circ$ .
6. Soupape selon la revendication 1, dans laquelle la surface supérieure dudit élément bouchon définit une surface de combustion (22) exposée aux pressions de combustion générées par ledit moteur, ladite surface étant une surface de révolution formée sous un premier angle (a) par rapport à une ligne perpendiculaire à l'axe longitudinal de ladite partie tige et la surface opposée à ladite surface de combustion étant formée sous un deuxième angle (b) par rapport à ladite ligne perpendiculaire à l'axe longitudinal de ladite partie tige.
7. Soupape selon la revendication 6, dans laquelle ledit premier angle est de zéro degré et ledit deuxième angle est de zéro degré.
8. Soupape selon la revendication 6, dans laquelle lesdits premier et deuxième angles sont chacun supérieurs à zéro degré et sont égaux.
9. Soupape selon la revendication 6, dans laquelle ledit premier angle est supérieur audit deuxième angle.
10. Soupape selon la revendication 6, dans laquelle ledit premier angle est inférieur audit deuxième angle.
11. Soupape selon l'une quelconque des revendications 6 à 10, dans laquelle ledit élément bouchon a une ou plusieurs nervures (28) disposées radialement formées sur celui-ci.
12. Soupape selon la revendication 1, caractérisée en ce que ladite soupape comprend une face (20) de contact avec le siège de soupape formée sur ledit élément bouchon.
13. Soupape selon la revendication 1, caractérisée par le fait que ladite soupape comporte une face (20b, 20c) de contact avec le siège de soupape formée sur ladite partie congé.
14. Soupape selon la revendication 1, dans laquelle ladite partie tige a une section de paroi suffisamment mince pour que le point de contrainte maximale de ladite soupape causée par les pressions de combustion créées par ledit moteur soit localisé en un point à au moins 70% de la distance radiale entre l'axe longitudinal et le bord externe de la soupape.
15. Soupape selon la revendication 1, caractérisée en ce que le rapport diamètre externe/diamètre interne dans la zone située entre la partie congé et l'extrémité de la partie pied est inférieur à 1,25.

16. Soupape selon l'une quelconque des revendications 1 à 15 comportant une ou plusieurs gorges (26) formées dans sa partie tige.
- 5 17. Méthode de fabrication d'une soupape en champignon ultralégère (10) selon l'une quelconque des revendications précédentes pour un moteur à combustion interne, caractérisée par les étapes d'approvisionnement d'une ébauche métallique plate, d'exposition de ladite ébauche (12a) à plusieurs étapes de façonnage à froid où des mandrins (30b, 30c, 30d) de diamètres décroissants et de longueurs croissantes sont successivement amenés au contact de ladite ébauche pour étirer celle-ci en un cylindre allongé (12, 16, 18) ayant une extrémité fermée sensiblement plate et une extrémité ouverte évasée, et de soudage d'un élément bouchon sensiblement discoïde sur ladite extrémité évasée.  
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18. Méthode selon la revendication 17 comprenant l'étape de façonnage une gorge annulaire sur ledit cylindre par déplacement de la paroi dudit cylindre vers l'intérieur.
- 15 19. Méthode selon la revendication 18, caractérisée en ce que ladite paroi est déplacée en immobilisant ledit cylindre entre des surfaces d'éléments outillages parallèles (32, 34) et en déplaçant lesdits éléments outillage dans des directions opposées parallèles auxdites surfaces, où l'un desdits éléments outillages a une saillie en forme de rampe (35) formée sur celui-ci.
- 20 20. Méthode selon la revendication 19, caractérisée en que l'autre élément outillage a une surface de frottement formée sur celui-ci et pouvant entrer en contact dudit cylindre.
21. Méthode selon l'une quelconque des revendications 17 à 20 comprenant l'étape d'adjonction d'un liquide de refroidissement à l'intérieur de ladite soupape avant ladite étape de soudage.  
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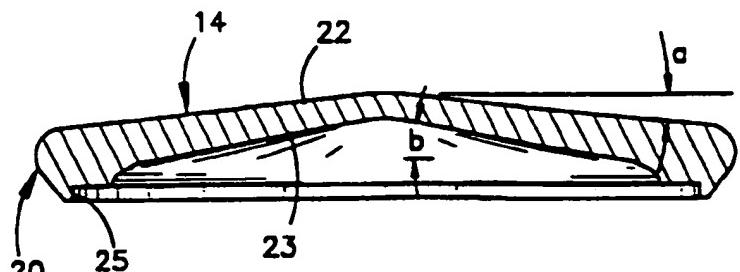


Fig.2A

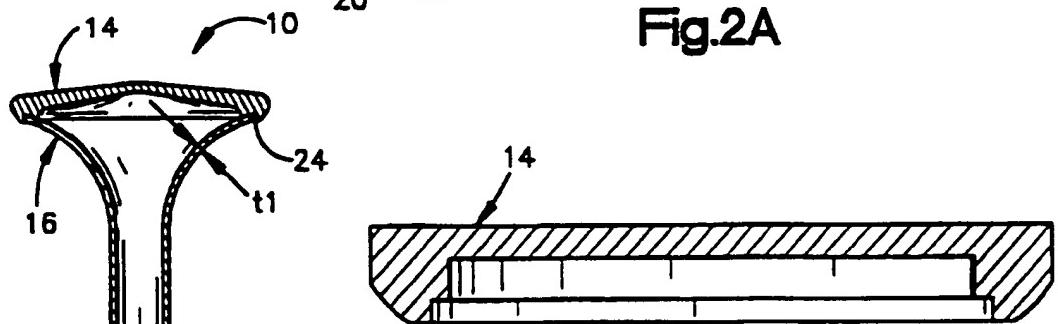


Fig.2B

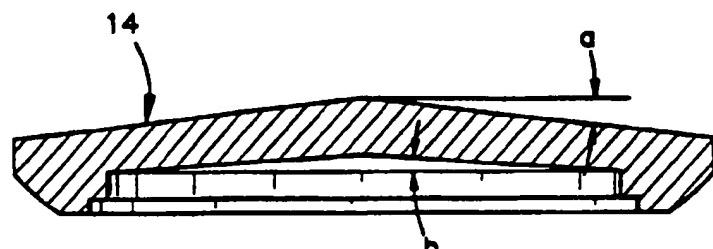


Fig.2C

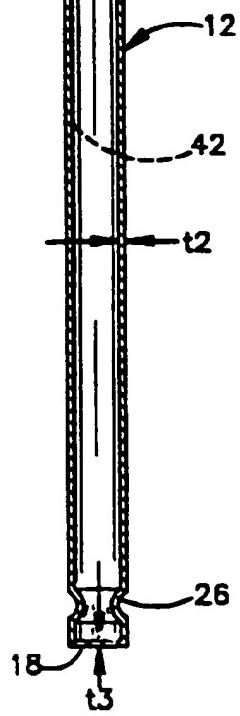


Fig.1

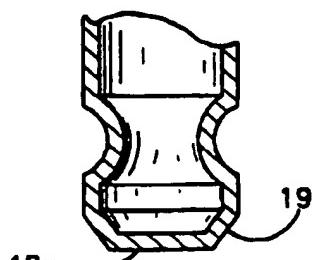


Fig.1A

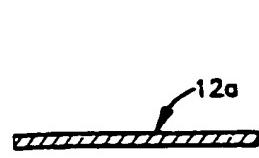


Fig.3A

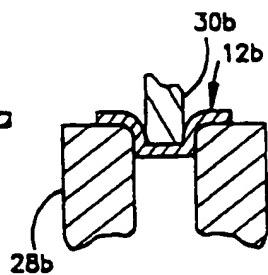


Fig.3B

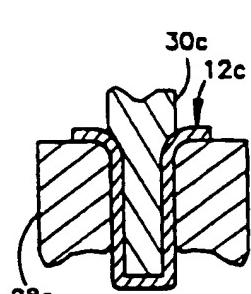


Fig.3C

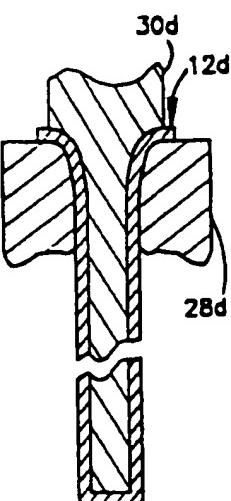


Fig.3D

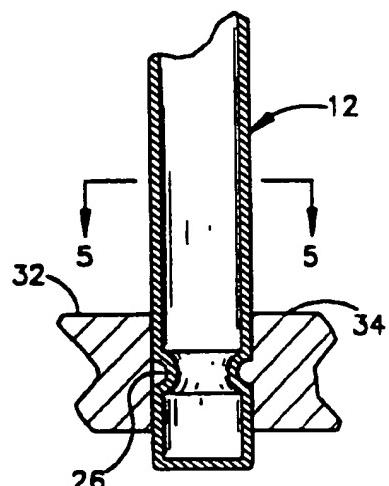


Fig.4

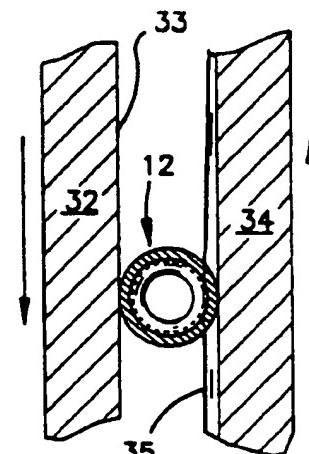


Fig.5

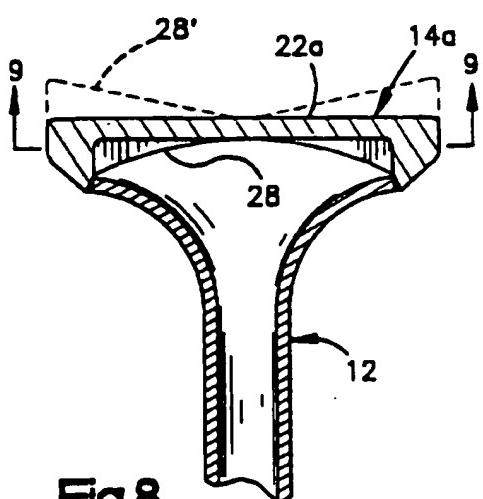


Fig.8

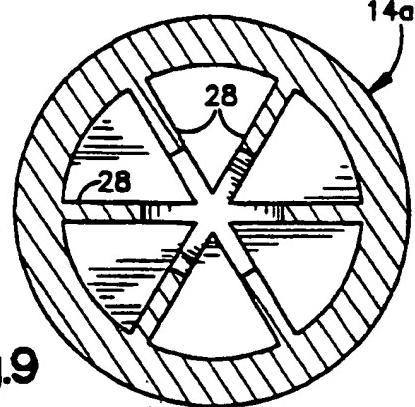


Fig.9

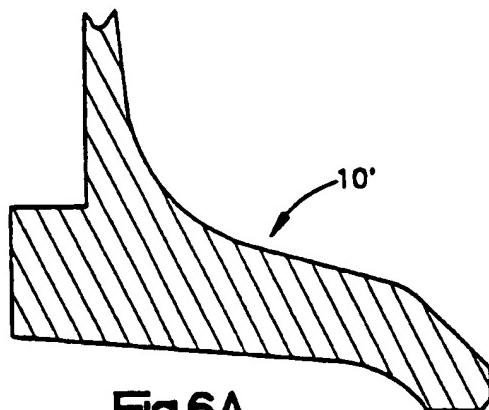


Fig.6A  
(PRIOR ART)

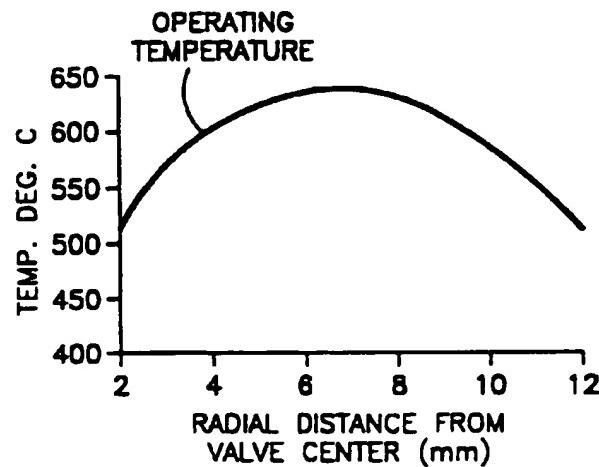


Fig.6B  
(PRIOR ART)

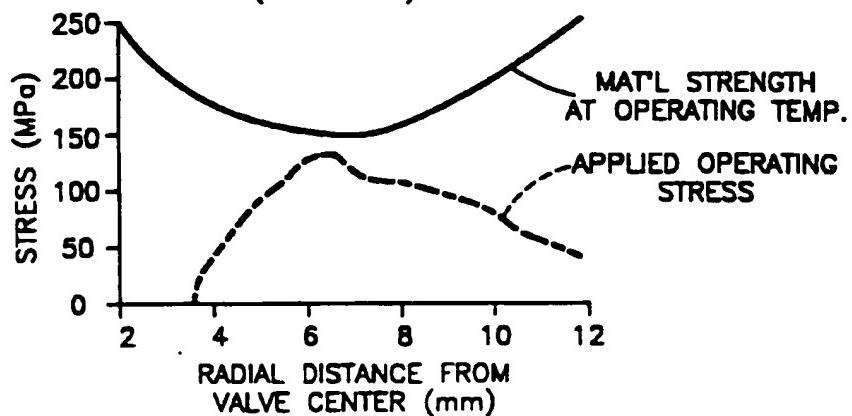


Fig.6C  
(PRIOR ART)

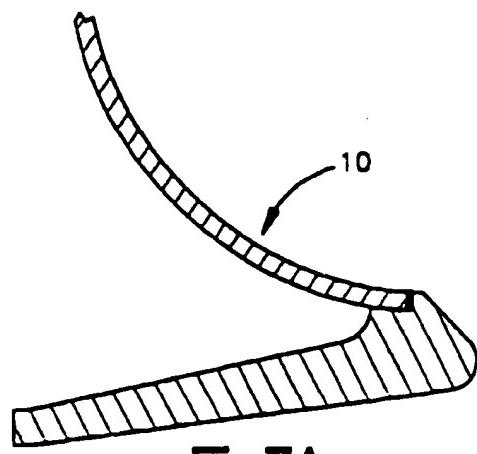


Fig.7A

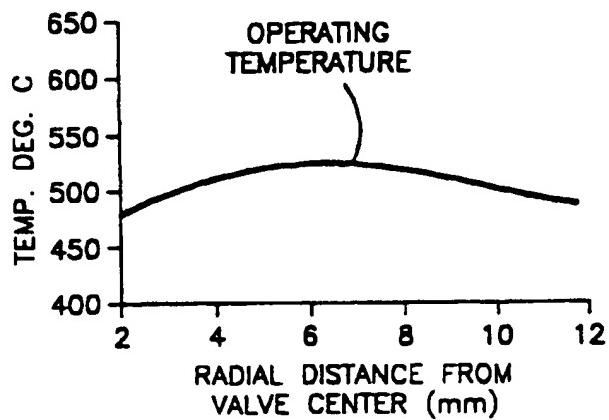


Fig.7B

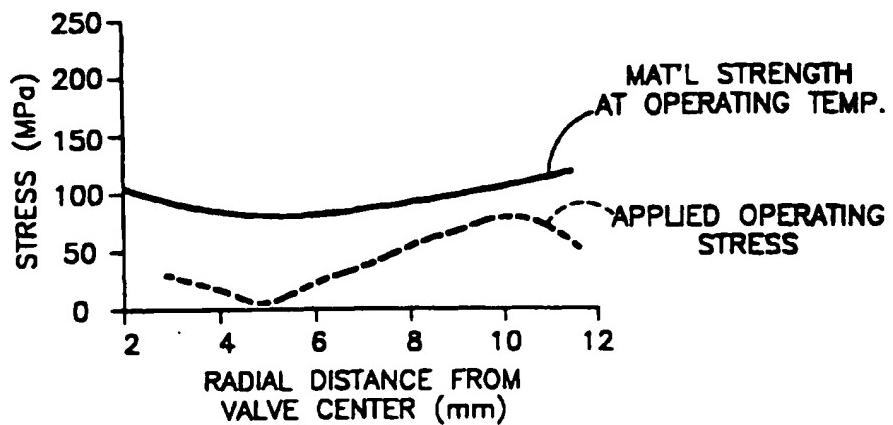


Fig.7C

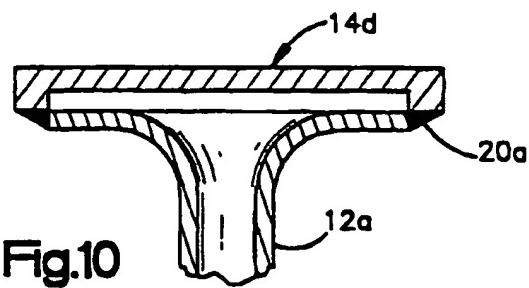


Fig.10

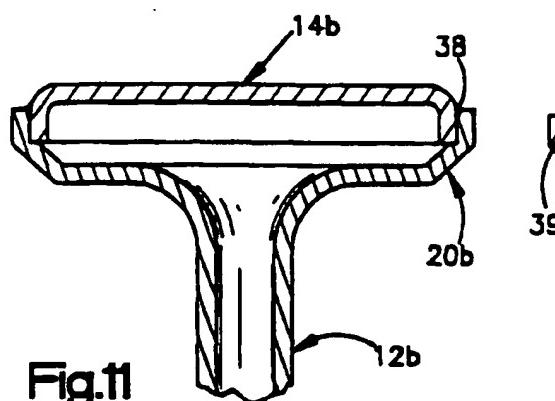


Fig.11

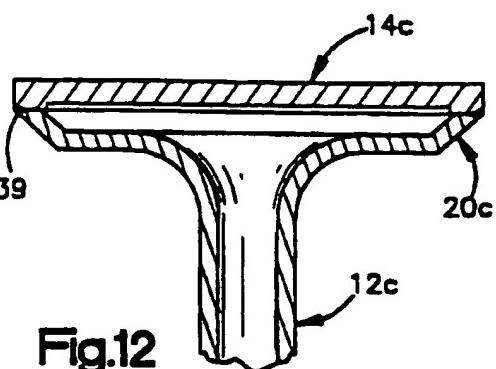


Fig.12

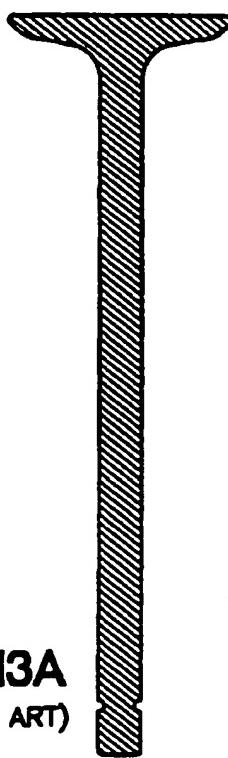


Fig.13A  
(PRIOR ART)

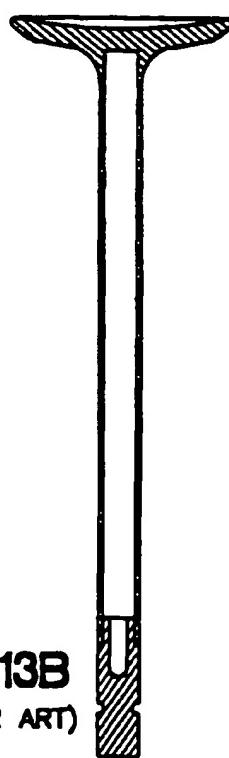


Fig.13B  
(PRIOR ART)

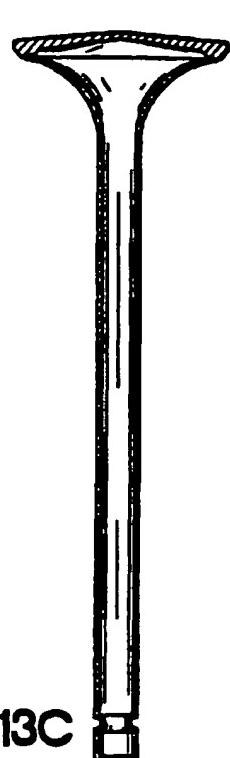


Fig.13C